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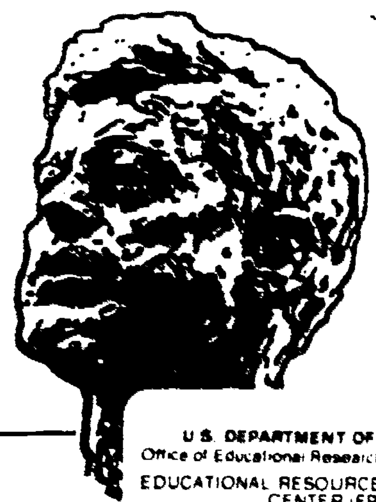
ABSTRACT

Curriculum-based measurement (CBM) is described as a method of helping teachers measure student performance accurately and adapt their instruction to improve student achievement. Curriculum-based measurement's features include measurement of student proficiency across the annual curriculum, and use of a standardized, prescriptive measurement methodology with demonstrated psychometric acceptability. Curriculum-based measurement is contrasted with the more predominant form of measurement known as mastery measurement. The use of CBM to develop effective instructional programs and to monitor and adjust goals is described. A study which evaluated the use of CBM with and without an expert consultation system in math operations is reported, with the finding that the instructional changes made by those teachers in the CBM group with expert consultation were superior in quality and variety to those made by the group without such consultation. Current research directions are also described, and a list of nine related readings is appended. (JDD)

Fred W

RESEARCH PROGRESS

John F. Kennedy Center



for Research on Education and Human Development
Peabody College, Vanderbilt University
May 1992

Linking Curriculum-Based Assessment to Instructional Decision Making

Enhancing Outcomes for Students at Risk for School Failure

By the year 2000, American students will leave grades four, eight, and twelve having demonstrated competency in challenging subject matter including English, mathematics, science, history, and geography; and every school in America will ensure that all students learn to use their minds well, so they may be prepared for responsible citizenship, further learning, and productive employment in our modern economy.

—*America 2000 National Education Goals for All Children*
Lamar Alexander, Secretary
U. S. Department of Education

If the nation is to meet its America 2000 goal of "demonstrated competency in challenging subject matter," teachers must be able to measure student achievement accurately and to adjust their instructional methods when students are not learning effectively. Instructional adaptation is increasingly important for two reasons. First, the diversity of students in public schools is increasing as the racial and ethnic make-up of the United States is changing. Many students have individual learning needs that, if ignored, increase their risk for school failure. Second, greater numbers of students with disabilities are receiving instruction in general education classrooms.

The necessary link between instructional decisions and student performance traditionally is provided by standardized achievement tests, but weaknesses associated with such tests have been well-documented. Some major limitations include infrequent measurement, limited match between curriculum content and test items, and lack of relevance for instructional decisions. Instead of using standardized tests, many teachers make instructional decisions based on unsystematic classroom observations, which tend to lack accuracy.

Kennedy Center investigator Lynn Fuchs* has been conducting a long-term research program on *Curriculum-Based Measurement* (CBM) that is helping teachers measure student performance accurately and adapt their instruction to improve student achievement. Fuchs's studies on CBM have involved general education and special education classes in public schools, and CBM has been implemented in mathematics, reading, and spelling. Over the course of this 15-year research program, the measurement system methodology, along with integrated instructional recommendation systems, have been refined. These systems signal teachers when instructional adjustments are needed to improve student performance, and suggest possible changes.

The Curriculum-Based Measurement Model

Curriculum-based measurement has two important features: (a) it measures student proficiency across the annual curriculum, and (b) it involves a standardized, prescriptive measurement methodology, with demonstrated psychometric acceptability.

**Associate Professor of Special Education, Peabody College, Vanderbilt University. Other Vanderbilt faculty involved in this research include Douglas Fuchs, Professor of Special Education and Kennedy Center investigator, and Carol Hamlett, Research Associate in Special Education; and teachers in Nashville Metropolitan Public Schools and the Williamson County School System. This research has been supported in part by Grant No. H023E90020 from the Office of Special Education Programs, U.S. Department of Education.*

To appreciate the distinctiveness of CBM, it is useful to contrast it to the more common, predominant form of instructionally related measurement known as *mastery measurement*. In this model, student mastery is described on a series of short-term instructional objectives. For example, a fourth-grade math teacher's objectives may involve being able to compute problems, first with multidigit addition, second with multidigit subtraction, third with multiplication facts, and so forth. To specify this mastery measurement system, a teacher must determine what a sensible sequence of instruction, or hierarchy of skills, would be, e.g., that instruction will begin with multidigit addition with regrouping, followed by multidigit subtraction with regrouping. Next, a teacher would design a criterion-referenced testing procedure to assess mastery at each step in the instructional sequence. The procedure might involve 25 comparable tests, each containing 10 problems that feature multidigit addition with regrouping, with all problems involving 3- or 4-digit numerals to maintain a comparable level of difficulty. The test would be presented, allowing 3 minutes for writing answers, and scoring performance in terms of the number of correct problems written in 3 minutes. A teacher might define mastery, for example, as eight correct problems in 3 minutes on 3 consecutive days. An instructor would begin by teaching multidigit addition with regrouping and then testing, and would teach and test until students have mastered this skill. Then measurement and instruction would shift to the next step in the skill hierarchy, multidigit subtraction. Thus, the test changes when the instruction changes. (See Figure 1A.)

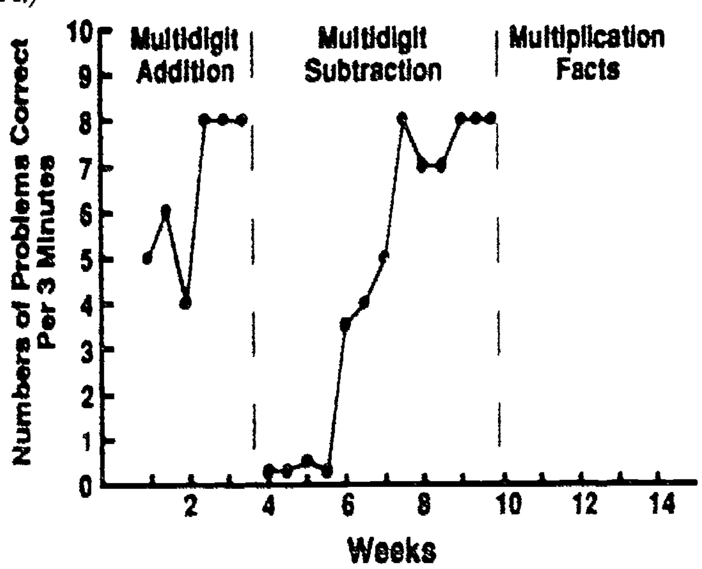


Fig. 1A. Example of a mastery measurement graph.

In contrast to mastery measurement, *curriculum-based measurement* has two primary features: (a) it assesses proficiency on all skills represented in the year-long curriculum; (2) it relies on standardized, prescriptive measurement methods.

Assuming the same general goal (proficiency on the fourth-grade computation curriculum), a teacher would determine the types of problems in the curriculum and their relative emphasis. Using randomly generated numerals, the teacher would create a series of alternate test forms. Each test would comprise 25 problems that represent the type and proportion of the problems constituting the fourth-grade curriculum. Students would have 3 minutes to complete as much of the test as possible; performance would be scored in terms of the number of digits correct. Each math test samples the year-long domain in the same way; each test is an alternate form that represents the fourth-grade curriculum. The test samples computation performance across the skills representing the curriculum.

During the first part of the year, a student would likely have poor mastery of the curriculum and thus low scores on the CBM test, e.g., 27 digits correct. The score does not communicate which skills in the curriculum have and have not been mastered; rather it indicates that few skills are mastered. By February, a student score may have increased to 51, and by the end of the year to 64. Scores are graphed throughout the year, providing a teacher with a visual picture of each student's progress. (See Figure 1B.)

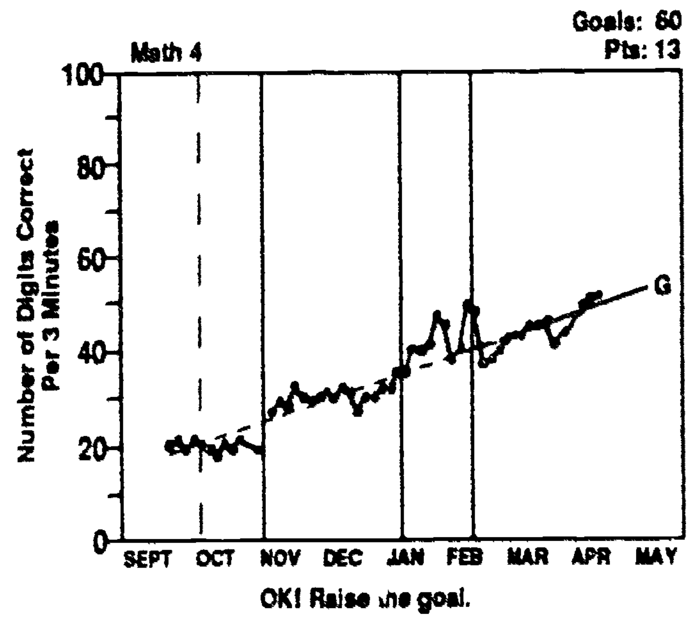


Fig. 1B. Example of a CBM math graph.

In addition to knowing the rate of student progress, teachers need to know which skills students have acquired. The CBM database can communicate which skills, or problem types, each student in the class has mastered. The skills profile (see Figure 2) provides an easy-to-read picture of a student's progress in mastering the range of problem types in the year's curriculum. The "Mastery Status" section provides data on a student's performance in the most recent halfmonth. The "Objectives History" provides

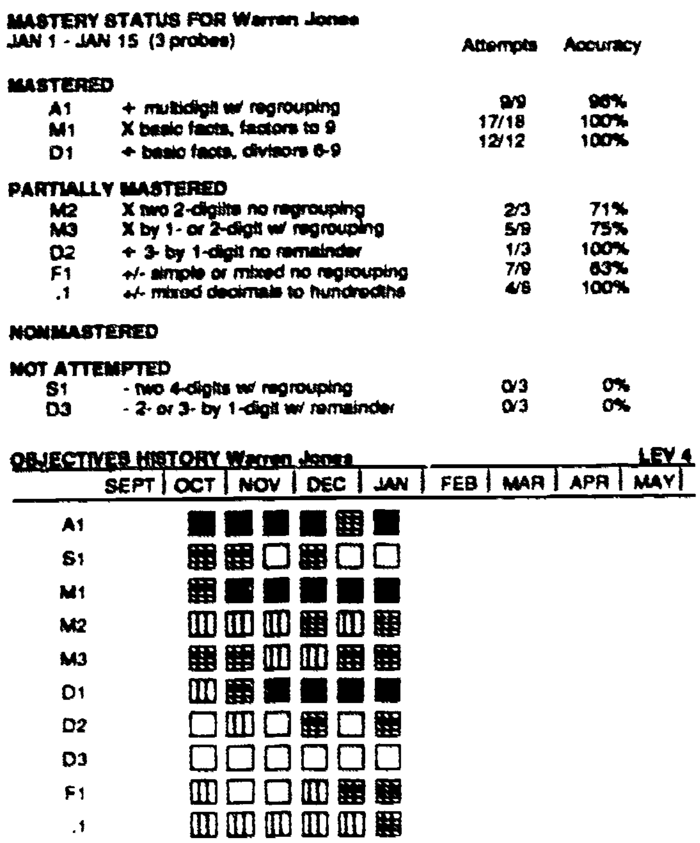


Fig. 2. Sample of a CBM Skills Analysis.

a visual summary of the student's performance over the year, with each block representing a halfmonth. A white box indicates that a student did not try this type of problem, a striped box that a student tried the problem type but did not do well, a checked box that a student has partially mastered the problem type, and a black box that a student has successfully mastered the problem type.

Distinctions Between CBM and Mastery Measurement

1. *Scope of skills for measurement.* Mastery measurement is focused narrowly on a single skill or a small cluster of skills at a time. By contrast, CBM is focused broadly on a large domain of skills over a year-long period. CBM may be less sensitive than mastery measurement to student change as a result of current instruction. However, compared to traditional measurement, where performance samples behavior across both grade levels and curricula at one moment in time, CBM provides information that is sensitive to instructional effects and can be used to improve instructional decision making. Because CBM describes student performance in terms of proficiency on the annual curriculum, both its content and criterion validity are stronger than with mastery measurement.

2. *Retention and generalization of skills.* With mastery measurement's close connection between testing and instruction, it does not automatically assess retention and generalization of skills. For example, when multidigit subtraction is being measured, a teacher does not know whether the previously mastered skill of multidigit addition has been maintained. CBM offers the advantage of automatically assessing retention and generalization of skills because each test incorporates all the problem types of the year's curriculum. CBM's sensitivity to retention and generalization learning may be critical when it is used to monitor the development of low-achieving students, since they frequently have poorly developed strategies for maintaining and transferring skills.

3. *Constancy in measurement across time.* Mastery measurement requires a shift in measurement each time a skill is mastered (see Figure 1A); CBM maintains a constant focus across the year (see Figure 1B). With mastery measurement, it is impossible to summarize an overall learning rate across the different skills in the curriculum, because different skills, measured at different times during the school year, are not of equal difficulty and do not represent equal curriculum units. With CBM, teachers may monitor students' basic skills development across a school year without any shifts in measurement. Because CBM tests sample across the entire year-long curriculum, test difficulty remains constant across the school year. The constancy associated with CBM permits summaries of student learning rates across time. The CBM database can be used to compare the effectiveness of different instructional components introduced at different times during the year.

4. *Reliance on instructional hierarchies.* The structure of mastery measurement specifies the order in which instruction must proceed, and one cannot progress to subsequent skills until mastery of the current skill is demonstrated. Moreover, the mastery measurement framework typically results in a skills-oriented approach to instruction. With mastery measurement, instruction (the independent variable) and measurement (the dependent variable) are tied together, with both simultaneously focused on skills. With CBM, the current instructional focus or procedure (the independent variable) is not tied to and determined by measurement (the dependent variable); therefore, measurement and instruction are not confounded. Because of this, CBM offers the advantage of permitting teachers to experiment with contrasting instructional chunks, sequences, and procedures. Teachers use the CBM database as the dependent variable by which they evaluate the effectiveness of contrasting instructional strategies.

5. *Development of tests.* Mastery measurement relies primarily on the use of teacher-made criterion-referenced tests, whose psychometric characteristics are unknown. Even when teachers rely on commercial criterion-referenced tests for mastery measurement, psychometric characteristics are uncertain. By contrast, a standard CBM methodology has been formulated. When teachers have determined the curriculum they expect students to master over the course of the school year, CBM prescribes methods for creating,

administering, scoring, and using tests that result in reliable and valid descriptions of students' growth in reading, spelling, written expression, and math operations and applications.

Using CBM to Develop Effective Instructional Programs

Fuchs's research shows that CBM does index student progress and achievement accurately and that, when used in certain ways, it can help teachers plan better instructional programs (Fuchs, Deno, & Mirkin, 1984).

Research supports three strategies for using CBM to assist teachers in developing instructional programs. First, teachers can use CBM to monitor the appropriateness of the goals they set and to ensure the use of realistic, but ambitious, goals (Fuchs, Fuchs, & Hamlett, 1989a). Second, CBM can be used to determine the adequacy of student progress, to determine whether instructional programs require adjustment, and to compare the effectiveness of alternative programmatic components (Fuchs, Fuchs, & Hamlett, 1989b). Finally, CBM databases can be used to draw profiles of strengths and weaknesses, in order to assist teachers in determining the nature of effective programmatic modifications (Fuchs, Fuchs, Hamlett, & Stecker, 1990). (For detail on these three strategies, see Fuchs, in press b.)

Using CBM to Monitor and Adjust Goals

Research substantiates the effectiveness of using goals to improve instructional outcomes. Within typical CBM practice, when a student's actual rate of progress falls below the rate necessary for goal attainment, the rate of a student's progress and the effectiveness of the instructional program are judged inadequate, and CBM decision rules recommend a teaching change. Thus, the performance criterion specified in the goal becomes critical in the instructional decision-making process. When teachers set goals that are unambitiously low, as is often the case for students with disabilities or other low-achieving students, few if any recommendations for instructional improvements will be made. Fuchs's research with CBM indicates that the level of goal ambitiousness, not goal attainment, is associated with student achievement.

Fuchs has explored dynamic goal setting as one potential solution to the problem of unambitious goals. Each of 30 special education teachers who taught self-contained and resource programs for students in grades 2 through 9 selected two mildly handicapped students with math goals in their Individualized Education Plans. Teachers were assigned randomly to three treatment groups: dynamic goal CBM, static goal CBM, and control. The control teachers monitored student progress using conventional special education practice, including unit tests, correction of assignments, and observation of student performance. The teachers in both CBM groups, over 15 weeks, used CBM to track their two pupils' progress toward math goals. Within the static goal CBM group, when a student's actual rate of improvement exceeded the rate anticipated in the goal line, the decision read "OK! Collect more data." The data pattern suggested that the student's rate of progress was acceptable with respect to goal attainment, and that the corresponding instructional program looked effective. The teachers always were free to increase the goal, but they were never directed to do so. By contrast, within the dynamic goal CBM group, when a student's actual rate of improvement exceeded the rate anticipated in the goal line, the decision read "OK! Raise the goal to X" (where X = the student's predicted performance at the end of the study, based on the student's current rate of progress).

With respect to use of goals, teachers in the dynamic goal CBM group made more goal increases than did teachers in the static goal CBM group. Most dramatic was the size of the effect. Within the dynamic goal group, teachers increased goals for more than one out of every two pupils; in the static goal group, only one teacher, for one of her pupils, spontaneously increased a goal in response to the student's data. This finding suggests that despite the potential importance of ambitious goals, special educators' typical goal-setting standards may underestimate many students' potential. It also suggests that without systematic prompting to raise goals, practitioners cannot be expected to do so.

A second major finding was that differential student achievement was concurrent with teachers' goal-raising behavior. Students in the dynamic goal CBM group achieved better than the controls during posttesting on a standardized math operations achievement test. However, the achievement of the static goal CBM group did not exceed that of the controls. Given the finding that such goal adjustment and goal ambitiousness may enhance student achievement, the special education community might consider adoption of CBM systems that incorporate dynamic goal-setting procedures.

CBM With and Without an Expert System in Math

Fuchs's research had demonstrated that CBM with consultation works better than consultation alone (Fuchs et al., 1984), but the effect of CBM when consultation was not in place was not known. The research team also was interested in finding a way to deliver consultation in a somewhat standardized way, and in a way that would be less expensive than frequent consultant visits. An "expert

system" was designed in math operations to provide that consultation. (An expert system is a computer program that tries to reproduce the advice that an expert might provide.) The research study addressed the question: What are the effects of an objective ongoing assessment system with and without "expert" instructional consultation on the amount and type of teacher instructional adaptation and on student achievement?

The expert system considered: information from the CBM database on individual and collective student performance; information about previous instructional programs (what has been tried with students) and the effects those programs had on student performance; teacher judgments about student work habits and motivation; and teacher curricular priorities. Based on this information, the expert system recommended what skills to work on next and alternative strategies for working on those skills. When appropriate, the expert system also recommended strategies for maintaining skills and for enhancing student motivation.

The study involved 33 special education teachers who had been randomly assigned to 3 groups; there were 11 teachers and close to 22 students in each group. The three groups were: CBM with expert consultation; CBM without consultation; and a control group without CBM. The intervention lasted for 20 weeks.

The following example serves to illustrate the process. Initially, a student was scoring 35 digits correct on the math operations curriculum, and the teacher set a goal of 57 digits correct. Software was used to graph the approximate rate of progress that the student needed to demonstrate in order to meet the goal in the time frame the teacher had set. If student progress was good, a recommendation directed the teacher to raise the goal, and a new progress rate was projected. After a month and a half, however, the assessment indicated that the student was not achieving the goal; so an instructional adjustment was recommended. A teacher in the group with expert system consultation would interact with the system to get suggestions about how to modify instruction. A teacher in the group without expert system consultation would develop alternative ideas independently. Teachers in both groups had access to student skills analyses.

Teachers in the CBM groups with and without consultation adapted instruction more frequently than did teachers in the control group. Teachers in the CBM groups made between two and three major instructional changes over the course of the intervention, but student achievement was better in the CBM group with consultation (an effect size of approximately one standard deviation, which is a reliable and practically important difference). (For more detail, see Fuchs, Fuchs, Hamlett, & Stecker, 1991.)

An important finding was that the instructional changes were superior in quality and variety in the CBM group with expert consultation. Teachers in this group taught a greater variety of problem types, especially multidigit subtraction, often a problem area for low-achieving students. They encouraged students to use "self-talk" strategies in solving problems. Teachers used a greater variety of algorithms, or different strategies, for teaching a given problem type. They used mixed problem types more frequently to maintain skills. Teachers in the nonexpert system groups relied on relatively low forms of instructional adaptation, essentially re-explaining or reviewing how to solve a problem, or using the same algorithm or strategy used previously but giving more practice time.

Findings in studies involving CBM with expert systems in math, reading, and spelling have been content specific, but across the three domains this finding was consistent: Without expert systems, teachers focus instructional changes on what to teach or re-teach. With expert systems, teachers focus on what and how to teach, i.e., not only content but also strategy or process.

Current Research Directions

Because of teachers' logistical problems in implementing many programmatic changes for different students at different times, Fuchs and her colleagues are developing and evaluating techniques for simultaneously considering the assessment information of all students in a class. These techniques focus on presenting classwide graphs and skills profiles and making instructional suggestions for groupings of students. The goal is to provide recommendations to teachers, which will improve whole-class instruction while at the same time tailoring some aspects of instruction for individual student needs, in both general education and special education classrooms.

Recommendations include the use of classwide peer tutoring, which provides a classroom organizational structure by which students in need of remediation in certain skill areas can be assisted by those who have mastered the specific skills. Over a period of time, the system can ensure that all students have opportunities to be "coaches" (i.e., tutors) as well as "players" (i.e., tutees). Preliminary findings suggest the potential power of the classwide applications for enhancing achievement outcomes for students with mild and moderate academic problems (Fuchs, in press a). Additionally, peer tutoring has proved to be a workable and effective method for providing differentiated instruction, where students receive formal instruction on different skills, within a large-group instructional setting.

The longstanding goal of Fuchs's research program on CBM is to investigate methods for integrating the use of ongoing assessment information with instructional planning, so that teachers can begin to address the diverse needs of their students effectively. The hope is that providing teachers with accurate assessment information, along with feasible routines for using that information to differentiate instruction, will increase our country's capacity to meet the challenge of helping American students leave school with academic competence, prepared for responsible citizenship and productive employment.

Related Readings

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About Research Progress

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